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The Lessons of the Iraq War:

Main Report

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(Note: This is the last prepublication version. The CSIS book to be published this fall will have substantial additions and corrections, and comments on this draft will be incorporated into the book, and the ongoing CSIS Lessons of War project. Comments -- and requests to cite, quote, or reproduce any part of this document should be requested in writing or by e-mail to acordesman@aol.com.)

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The reader should also be aware that this book makes extensive use of reporting on the war from a wide range of press sources, only some of which can be fully footnoted, interviews with serving and retired officers involved in various aspects of the planning and execution of the war, and the extensive work done by Australian, British, and US officers in preparing daily briefings and official background materials on the conflict.

The Coalition Application of Airpower

The fact that the United States and Britain had in many ways defeated the Iraqi Air Force in the air and had heavily suppressed the Iraqi land-based air defense system, even before the war began, allowed the Coalition to suppress Iraq's air defenses with remarkable speed and to concentrate on strike/attack missions almost immediately. A monopoly of stealth and cruise missiles allowed the Coalition to attack any static target in even the most heavily defended air space at any time in any weather. As the following chapter shows, the Coalition leapt from air supremacy to nearly total air dominance.

No public battle damage assessment data (BDA) are available to assess the level of damage the Coalition inflicted, and few data are as yet available on the effectiveness of individual aircraft and systems. Still, enough data are available from previous wars to show that a force ratio of over 18,000 well-directed precision guided weapons to zero, plus thousands more unguided weapons, must have had a massive effect. It certainly makes conventional force ratio and order-of-battle comparisons largely meaningless.

Effects-based Bombing

More was involved than the ability to use airpower as a killing mechanism. The Coalition could use precision-guided weapons and advanced U.S. command and control and targeting assets to limit collateral damage and civilian casualties. It could use new intelligence assets and targeting planning to severely limit the number of targets it had to strike and then carefully match weapon accuracy and reliability, and the size and effect of the weapon, to the right aim point necessary to destroy the function of a target without imposing unnecessary destruction or risk to the target and target area.

This, in turn, allowed the United States and Britain to seek to paralyze and destroy a regime, not bomb a country. It allowed them to avoid attacking most urban and populated areas unless there were time-urgent regime targets or Iraqi forces that actively threatened Coalition forces.

This issue of "time urgency" for a regime the Coalition expected to survive for only weeks at most, and that it expected to lose control over most of the country in days, was also a critical one. The Coalition had no need to bomb liberated or passive areas and Iraqi forces. It had no reason to strike at economic targets unless there were actively hostile Iraqi forces in them or a time-urgent risk that such targets could lead to the Iraqi use of WMD or missiles. There was no need for extensive attacks on economic or infrastructure facilities, lines of communication, or most other civilian targets.

Anything But a Cakewalk

At the same time, "effects-based bombing" remained an art form and not a science. One key problem, even with the targeting and intelligence assets the coalition had available, was knowing how many fixed targets were empty, or no longer performed a critical function, and how many Iraqi forces were able to disperse. Although no data are available on this aspect of the Iraq War, some of those involved in battle damage assessment in Desert Fox in 1998 feel the United States found that at least 20 to 30 percent of strikes hit largely empty buildings or facilities. Others indicate that the coalition often struck at facilities simply because they were associated with the military or had special security. In many cases, the US did not know the function of the facility before the war with any confidence and had no way to estimate the impact of such strikes..

The Iraqis had learned from the Israeli strike on Osirak in 1982 that they should build the walls and roofs of structures before creating underground facilities and structures or putting in the final structure in terms of floors and special features. They made increasing use of deep shelters and tunnels whose character could be concealed for satellites and reconnaissance aircraft, and learned how to carry out activities where US satellite coverage was limited, and exploited the intelligence the US gave them during the Iran-Iraq War to predict some of the limits to US sources and methods This learning process continued when Iraq aided Serbia during the Kosovo crisis. The Iraqis had months to quietly prepare alternative sites, decoys, deception operations, and force dispersal.

Targeting was easier against conventional land, air, air defense, and naval forces that remained in or near their peacetime locations, but moment the war began, many Iraqi forces began to move, and the Iraqi force mix changed. US and British intelligence also was far less capable in locating and characterizing people and vehicles that were or looked like civilian vehicles. As a result, it had major problems in dealing with infantry-dominated forces, light forces, and irregular forces like Saddam's Fedayeen. These problems were compounded by their inability to accurately characterize the warfighting capability of intelligence, security, Ba'ath Party, and paramilitary forces; and by the increasing intermingling of such forces with elements of the regular army and the Republican Guards as the war progressed.

As a result, U.S. targeting had to become dynamic and had to alter to hit at newly discovered or dispersed targets by the second day of operations. It then had to stay fluid and be shaped by the changing tactical situation, the discovery of new patterns in Iraqi military activity and dispersal, efforts to assess the damage done by previous air strikes and Iraqi engagements with coalition ground forces, and the concentration of the enemy near American and British forces. Events increasingly dictated targeting in ways that had to be based on less and less certain information as the battle became more dynamic, and these problems seem to have increased because of a relatively early breakdown in the battle damage assessment effort.

The dynamics of combat also affected the level of restraint the Coalition could show. The allies still had to protect American, Australian, and British soldiers, their rear areas, and their flanks, and do so even in urban areas. Senior U.S. military officers said before the war that the coalition would hit whatever was necessary to do this, and that **they** still planned to use a total of 30 percent unguided weapons—although this total was around 10 percent in populated or sensitive areas.

The Coalition flew extensive numbers of sorties where no central control could be exerted over the targets that were engaged. Aircraft flew in "kill boxes" and attacked targets of opportunity in the rear or provided close air support. There were many areas where the pilots of fixed-wing and rotary wing aircraft performed their own targeting on a target-of-opportunity basis, supported by their individual formation.

Targeting restraints had to be different in the case of known or suspected locations with chemical and biological weapon (CBW) or key related delivery systems. The United States and Britain could make maximum use of precision weapons and try to use the smallest weapon that could take out most CBW systems while limiting the risk of collateral damage.. At the same time, the Coalition had massive intelligence problems in locating and characterizing the targets involved, just as it had had during the previous Gulf War. It is now clear that many targets were hit that had little or no impact on any Iraqi capability to launch missiles or deliver either chemical or biological weapons. It was forced to bomb many targets simply because a successful Iraqi use of weapons of mass destruction on U.S., British, and Australian troops could have produced a massive increase in coalition casualties.

Once again, targeting was complicated by the fact that Iraq had every reason to try to disperse, use decoys, shelter in civilian areas and facilities, and use sensitive buildings and areas to limit American and British effectiveness. It had equal reason to exaggerate military and civilian casualties, religious and cultural destruction, and economic and infrastructure destruction for political purposes.

Urban and heavily populated areas presented a problem. Most urban areas were still open enough to allow the use of precision weapons. Many Iraqi regime facilities were surrounded by compounds and wide areas that allowed fighting to avoid densely populated areas, and civilians fled most adjacent areas or successfully took cover. Nevertheless, close-in urban fighting still happened in populated areas where the US and Britain could not launch air of missile strikes without risking significant collateral damage particularly in the cities the Coalition advanced through in the south and from Baghdad's outer defenses to the last core center of the regime. One senior U.S. military targeting expert called this kind of targeting "trying to have a fist fight in a really dark room." The United States, Britain, and Australia could not let soldiers engage in such fighting because of targeting constraints.

All of these issues meant that the United States and Britain had to react with rapid retargeting and bombing with progressively less information. There were also many real world constraints on “precision,” Targeting and location errors were inevitable in such a massive campaign. The theoretical design accuracy of targeting systems, avionics, and precision weapons was also generally much higher than the real world performance of the delivery system and weapon in actual combat. Reliability problems and manufacturing errors meant many weapons did not achieve their design accuracy, significant numbers of misses occurred, and warheads or munitions misfired.

The US,, Britain, and Australia have not made any BDA data public which can be used to analyze how effectively the Coalition air forces dealt with these problems. As has been touched upon earlier, some of the senior officers involved also indicate that the BDA analysis effort broke down early in the war and made it extremely difficult to assess “effects” on a timely basis. Moreover, even if some Coalition member does publish public battle damage assessment data, these data may have uncertain value. Much of U.S. and British battle damage analysis is based on whether a strike destroys the desired part of the building or hit the correct area. There is no way to be sure who is in the building or shelter, or how much their strikes have hurt the functional capabilities of Iraqi forces. Similarly, the assessment of damage of major weapons systems often has to be probabilistic because universal sensor coverage is impossible, the full nature and cause of the damage done to a weapon is not clear from the sensor, and the use of multiple collection assets and pilot reports leads to dual counting. Despite all of the advances in technology, there often is still no way to reliably measure or verify lethality, and particularly to assess military and civilian casualties and the economic and function impact of collateral damage.

Nevertheless, the e Coalition did make extensive use of intelligence satellites, UAVs like Predator and Global Hawk, reconnaissance aircraft like the U-2, targeting aircraft like the E-8C JSTARS, helicopters, and Special Forces to maintain their targeting capability. It drew on US resources which provided unprecedented intelligence assets, communications, and computer speed in acquiring, reviewing, and allocating targets. The fog of war must have remained, but it was certainly thinned.

The end result, at least from the evidence provided by media coverage to date, is that civilian casualties and collateral damage were remarkably limited and that postwar looting may actually have caused more damage than the coalition.

The Impact of Space Warfare

Space is scarcely a traditional fundamental of war. But it has been a fundamental ever since the United States first made use of satellites for intelligence purposes. In the Iraq

War, the United States used space for battle management, for communications, to locate its forces and guide its weapons, and to perform a wide range of other missions. It built upon the lessons of the Gulf War and Afghan War and on progress in worldwide communications dating back to the days of Vietnam. At the same time, this was the first large-scale war in which the United States could fight with 24-hour continuing intelligence satellite and sensor coverage over the battlefield, as well as the first major conflict where it could take advantage of full 24-hour coverage by global positioning satellite (GPS) system.

Overall Coalition Superiority

The United States and Britain did not have total dominance of space. Iraq had access to satellites for television transmittal during much of the war and was able to use friendly Arab satellite media to make its case. It had purchased large amounts of commercial satellite photography both directly and through various fronts before the war, and it could make commercial use of the global positioning satellite system.[103]

The Coalition had so great a superiority in every area of space, however, that Iraq's capabilities were trivial in comparison. The United States was able to build upon the lessons of both the Gulf War and the war in Afghanistan, and although the strengths and weaknesses of its space-centered efforts may remain classified for years, it is clear that major progress was made. One press report indicates that the United States made use of more than 50 satellites during the war, including the two dozen satellites in the GPS system.

Space provided a wide range of intelligence, targeting, and battle damage assessment capabilities. It was the key to effective command and control and to netted global military communications. The range of space-based communications and sensor assets, and the vast bandwidth the United States could bring to managing global military operations, allowed it to achieve near-real-time command and control and intelligence collection, processing, and dissemination. At the same time, GPS allowed U.S. and British forces to locate friendly and enemy forces and both target and guide weapons. The United States also made use of satellites to locate missile launches, predict their target, and provide warning.[104] USCENTAF reports that U.S. infrared satellites detected some 26 Iraqi missile launches, 1,493 static events, 186 high-explosive events, 40 hook bursts, and 48 ATACMs events.[105]

Evolving Space into Jointness

At the operational level, a decade of command experience by U.S. Air Force, Army, and Navy commanders who stressed joint operations had helped transform the space operations community from a secretive scientific-based one to a specialized cadre integrated with air, land, and sea combat forces.

Some of this success may stem from organizational changes made in 2002. Previous commanders of the Air Force Space Command (AFSPC) also served as commander in chief of the U.S. Space and the North American Aerospace Defense commands, splitting their time among the three. On April 19, 2002, General Lance W. Lord was made a full-time commander of AFSPC. General Lord summarized the role of space in the Iraq War as follows:[106]

> During the Gulf War, milspace was in its formative stages. We only had 16-17 GPS satellites back then [for example]. That was a rudimentary capability compared to what we have now.…[Our] people are deployed throughout the Centcom [Central Command] Area of Responsibility…and are part of the Expeditionary Air Force, that's for sure.
>
> One place you see [milspace] capabilities come to bear is in the Combined Air Operations Center at Prince Sultan AB in Saudi Arabia. We have a space team on duty round-the-clock in the CAOC, helping coordinate GPS, intelligence, surveillance, reconnaissance, weather, and communications—all the things "space" is capable of doing.
>
> It makes sure "space" is fully integrated into any campaign planning and operations [now], and will be fully integrated into any future [war] operations.… I think they're growing, and we're out there, spreading the word that we're part of the team.…We're really hitting our stride [now]. It's getting better all the time.

One article described the transformation as one from "space geeks" to "space-smart" officers in an environment where enlisted troops worked closely with traditional warfighters in Combined Air Operations Centers (CAOCs). Air strike planners regularly obtained advice and inputs from military space experts on how to ensure that a number of GPS satellites would be in view over a target area, particularly when GPS-aided weapons were to be delivered. The same was true of coordination in using satellite-derived weather information and imagery of target areas and in conducting network-centric operations and using space-based communication links.

These changes did much to break down the intelligence rivalries, compartmentation, and emphasis on "keeping the secrets" that badly hurt the space effort during the Gulf War—although preliminary conversations indicate that they scarcely solved the problem. [107] There is still a need to redefine "jointness" so that the entire Intelligence Community plays a suitable role in warfighting. Agencies like the CIA, NRO, and NSA may be civilian – and certainly has many other tasks and responsibilities – but they are also a critical part of modern joint and netcentric warfare. Good answers need to be found to fully integrating them into modern military operations, and into joint commands. Moreover, field reports indicate that there are still too many barriers at every level in the chain to the properly flow and dissemination of information because of security classification. As one warfighter put it, "security officers are supposed to be on our side, not on the side of the enemy."

The US Army has also been slower than the Air Force to fully integrate space into its operations. It has updated some of its space policy as a result of the Iraq War, updating a policy dating back to 1994. It has been slow, however, to develop effective tasking arrangements for imagery satellites with the NRO, and some Army experts feel it has been slow to seek more secure GPS technology.[108]

Space and Communications

The space effort in the Iraq War benefited from improved communications, integration, data processing and analytic methods, and command and control at every level. National, theater, and tactical intelligence had much better integration, processing, and dissemination than during the Gulf War, building on the lessons of that conflict and Afghanistan. As in the Gulf and Afghan Wars, however, space was particularly important to military communications. Work by the Marine Corps Systems Command (MCSC) on the lessons of the war illustrates just how vital space communications were to the Coalition's success:

> Interoperability of various Communications equipment was an issue in all C3 vehicles and COCs (Tanks, LAR, AAVs). Marines were overwhelmed with the high number of varied communications equipment they were expected to use. Routinely, communicators, operations officers, and commanders found themselves in information overload as they received information over too many different networks (e.g., an LAV Marine was connected to the intercom via his CVC headset, receiving information on a personal intra squad radio (requiring him to remove his helmet to talk), while also (depending on the particular LAVs configuration) "working" 2-3 man portable radios to communicate with other units (PVC 5 for SEALs, PRC 148 for fellow Marines, etc.) and "monitoring" two laptops). This situation was exacerbated in C3 vehicles where I personally saw that every "shelf" was taken up by a radio and seat spaces and floor spaces were taken up with open computers for communications devices such as Blue Force Tracker, MDACT, or Iridium phones. Marines recounted numerous instances where units would call via radio to verify that a message was received over MDACT, while the receiving unit had just put the MDACT aside to monitor BFT since a previous unit had called asking about the receipt of a digital photo over BFT. Consolidation of communications assets/capabilities is an issue that requires review at the institutional level. Commanders want one box that provides multiple capabilities and that is simple and easy to use.
>
> Overwhelmingly, units were in agreement that communications architecture required an overhaul. There were too many different devices that provided redundant capabilities. Additionally, units never seemed to receive enough of *one* communications asset, forcing them to rely on a "hodge-podge" of assets that were not consistent throughout the force. (E.g., some units had only MDACT for digital communication while another unit had only Blue Force Tracker. These units could not talk to each other unless they went through a third party or used a courier system.) A specific case occurred between LAR S-2 and the Div G-2 while attempting to send pictures from the Dragon Eye to Division HQ G-2. The S-2 had BFT readily available while the G-2 did not. The G-2 needed to "borrow" the commander's BFT to receive these messages or simply wait for a courier with a MEMOREX disk to arrive with the pictures. Time lost often rendered the pictures irrelevant in this fast-paced fight. As the Operations Officer from 1st LAR stated, "the communications architecture is broken and the interoperability of various communications assets is virtually non-existent."
>
> …The only consistently reliable means of communication was "SATCOM." In this fast-paced war, if a communications system was not functioning quickly, alternative methods were employed. This was a specific problem of the EPLRS radio (which relies on Line of Site (LOS). With units constantly moving over various terrain, LOS was not possible. Accordingly, any system connected to the EPLRS radio proved unreliable (e.g., MDACT, AFATDS, etc.). The only systems consistently praised by the Marines were the Blue Force Tracker (SATCOM—though unsecure) and Iridium Phones (SATCOM). These systems provided reliable communications at all times. In many instances these systems were the sole means of communication.
>
> Many Marines noted MDACT, which has a larger bandwidth and greater capability for sending electronic information, was marginalized by its dependence on the EPLRS (LOS) radio. As one commander stated, "Satellite Communications is simply the way of the future and the Marine Corps needs to start focusing on that." Rumor suggested the Army "gave" the Marine Corps satellite time [*note: I believe the USMC contracted bandwidth prior to crossing the LD*] in order to use the BFT; had this not been the case, the Marine Corps would have found itself fighting, in several instances, without tactical communication.

The Ongoing Evolution of Space

The United States and Britain made use of numerous communications satellites and about half a dozen electro-optical and signals intelligence satellites. A press report indicates that the National Reconnaissance Office (NRO) employed three advanced "KH-11"-type visible and infrared imaging satellites and 2–3 “Lacrosse”-type all-weather imaging radar satellites that proved especially effective in spotting armored movements and whose data were used in conjunction with data from the E-8C JSTARS. At least one of these satellites could image the battlefield every 2–3 hours, and they made some 12 passes per day. A total of some 33,500 personnel at 21 U.S. sites and 15 foreign locations were involved in the overall space support effort.[109]

Press reports, however, can only hint at the overall architecture and capabilities of U.S. space systems and how rapidly they are evolving. As a result, there is no way to quantify or describe recent and planned changes in U.S. space capabilities in detail. Unclassified discussions of the increase in satellite imagery (PHOTINT) coverage and capability simply cannot be grounded in reality, although the level of resolution and “24/7” persistence of coverage has clearly changed radically. The same is true of any effort to provide an unclassified analysis of the much more complicated problems of assessing the trends in space-based electronic intelligence (ELINT) and signals intelligence (SIGINT).

What is clear is that advances in data processing and the ability to develop complex “mosaics” of all forms of space intelligence are now being mixed in near-real-time with improved airborne platform coverage of imagery, ELINT, and SIGINT and processing of human intelligence (HUMINT), data from ground units like Special Forces, and open sources. The end result is a new form of space-centered joint intelligence that has led to a massive improvement in situational awareness and targeting capability that is one of the keys to precision warfare and rapid maneuver.

At the same time, those involved in operating and upgrading U.S. space systems are among the first to say that space warfare is still in its early days. Much of the ability to net, process, and utilize space capabilities remains relatively primitive compared to its potential; the human factors and ergonomics of space exploitation remain crude; and joint warfare is only beginning to exploit the potential of space-centered warfare.

The Importance of GPS

The importance of the global positioning satellite system is illustrated by the fact that when GPS was introduced into the U.S. Army during the Gulf War, there was a maximum of one receiver per company or 180 men. In the Iraq War, there were more than 100,000 Precision Lightweight GPS Receivers (PLGRs) for the land forces and at least one per nine-man squad. The marines had fewer units, but still had 5,400, or roughly one per platoon (3–5 squads.) Moreover, a number of marines carried their own civilian GPS units.[110]

These advances scarcely solved all military navigation and guidance problems. In one highly publicized incident near Nasiryah, members of the U.S. Army’s 507th Maintenance Company got lost and ran into an ambush. Eight servicemen were killed and six were taken prisoner. It is far from clear, however, that this was related to the capabilities of the GPS system.

In any case, the technology in future wars is likely to be much better. The PLGR now costs roughly $1,000 and weighs about 2.75 pounds, and it is accurate to within 10 yards versus 20–25 yards for civilian units. It does not, however, display maps, only location and velocity. In contrast, the new FBCB2 system introduced in U.S. Army combat vehicles during the war does allow broad electronic display of the battlefield and can track friendly forces using their GPS information and red forces using intelligence with GPS coordinates.[111]

The United States is also developing a new generation of hand-held GPS systems called the Defense Advanced GPS Receiver, or DAGR, which will be more accurate and more resistant to jamming. It also will have a mapping system that displays both red-blue forces and key terrain features and obstacles like minefields and rivers. The one-pound device can be plugged into military radios to communicate location data.

The GPS systems used by the land forces now run on the same 1,575 megahertz frequency as civilian systems, although the military system is encrypted. The new systems for land forces will use the much more secure military frequency of 1,227 megahertz that is used by combat aircraft, cruise missiles, and other airborne systems. They will be able to track all 12 GPS satellites in a given hemisphere at once, versus 5 for the current systems, and they will have classified technology to verify that the devices are reading only U.S. military signals and not jamming or deception signals from the enemy.

GPS Jammers and Countermeasures

Although Iraq had at least four jammers designed to jam the Coalition GPS system, these seem to have been destroyed early in the war and to have had little operational effectiveness. According to one press report, the jammers were successfully attacked by B-1Bs and F-117s; at least some seem to have been attacked with GPS- guided weapons.[112] The very fact such jammers existed, however, is a warning that eventually there is a countermeasure to virtually every tactic and technology. It is also a lesson that GPS modernization remains a critical priority.[113]

The GPS satellite signal is roughly equivalent to the light from a 25-watt bulb at a distance of 11,000 miles. The Russian firm Aviaconversia claims that its low-power 4-watt jammer can block a receiver from picking up signals up to 124 miles away if there is line of sight. One explanation is that military GPS signals are roughly 1,000 times stronger than civilian signals when they are locked into their military frequency and use the military P-code. As a result, a jammer with a potential jamming range of 100 miles against a civilian unit will only work for a few miles against a military unit. These counterjamming capabilities are also expected to increase strikingly in the near future when the United States deploys the G-STAR, a system designed to block the jamming signal and direct the GPS unit to use beam steering to look for other satellites. (Most GPS guided weapons have a fallback. For example, the JDAM defaults to inertial guidance, although its accuracy degrades from an average of around 40 feet to 100 feet.)

VII. LESSONS AFFECTING THE OVERALL CONDUCT OF THE WAR AND JOINT FORCES

There is never a clean break between the lessons of war that emerged long before the Trojan War, or in Thucydides and Sun Tsu, and the lessons that are specific to a modern conflict. This is particularly true of jointness, which the previous chapter has discussed in terms of fundamentals. On the one hand, the improvements in jointness are the result of a long process of evolution. On the other hand, the actual practice of jointness has changed radically even since the Gulf War of 1991.

The very term "jointness" took on a new meaning during the Iraq War in terms of speed of maneuver, tempo of operations, precision, lethality, intelligence, targeting and battle management. In his March 22 USCENTCOM briefing on the course of the war, General Tommy Franks described the importance of these changes as follows:[134]

> Let me begin by saying this will be a campaign unlike any other in history, a campaign characterized by shock, by surprise, by flexibility, by the employment of precise munitions on a scale never before seen, and by the application of overwhelming force.
>
> Let me talk for a minute about our capabilities. The coalition now engaged in and supporting Operation Iraqi Freedom includes Army and Marine forces from the land component; air forces from several nations; naval forces, to include the Coast Guard, and Special Operations forces.
>
> Our plan introduces these forces across the breadth and depth of Iraq, in some cases simultaneously and in some cases sequentially. In some cases, our Special Operations forces support conventional ground forces. Examples of this include operations behind enemy lines to attack enemy positions and formations or perhaps to secure bridges and crossing sites over rivers or perhaps to secure key installations, like the gas-oil platforms, and, of course, in some cases, to adjust air power, as we saw in Afghanistan.
>
> Now, in some cases, our air forces support ground elements or support special operations forces by providing targeting and intelligence information, perhaps offensive electronic warfare capabilities. At other times, coalition airmen deliver decisive precision shock, such as you witnessed beginning last night.
>
> At certain points, special operations forces and ground units support air forces by pushing enemy formations into positions to be destroyed by air power. And in yet other cases, our naval elements support air, support ground operations, or support Special Operations forces by providing aircraft, cruise missiles, or by conducting maritime operations or mine-clearing operations.
>
> And so the plan we see uses combinations of these capabilities that I've just described. It uses them at times and in places of our choosing in order to accomplish the objectives I mentioned just a moment ago.
>
> That plan gives commanders at all levels and it gives me latitude to build the mosaic I just described in a way that provides flexibility so that we can attack the enemy on our terms, and we are doing so.

For all the limits of jointness described in chapter 6 and in the detailed lessons in the chapters that follow, the different problems that emerge reflect a need for improved execution of jointness, and they in no way challenge the validity of the concepts the United States is now pursuing. In fact, in virtually every case, there is substantial interaction between lessons that affect jointness and individual lessons affecting the military services or key weapons and tactics.

Landpower-Reinforced Airpower and Vice Versa

A case in point is the extent to which landpower reinforced airpower and vice versa. The Iraqi land forces were forced to expose themselves by the speed of land operations and then were hit hard from the air, which in turn sharply reduced the Iraqi threat to U.S. and British land forces. Jointness took on a new practical meaning.

These interactions between landpower and airpower may take some time to sort out. Nonetheless, there seems to be a significant contrast between the conduct of the Iraq War and the Gulf War. The long air bombardment in the Gulf War produced a focus on air operations that led some to concentrate on airpower to the exclusion of land power and to claim that airpower alone could be decisive. It also led some to claim that strategic bombing had a decisive effect. In reality, the USAF Gulf War Airpower Survey showed that General Horner, commander the air effort during the Gulf War, was correct in totally rejecting initial plans to focus on strategic bombing at the expense of a proper balance of land forces. Similarly, the role of airpower in Afghanistan against an enemy with virtually no modern weapons led to similar claims about the decisive impact of airpower by those whom General Horner came to call “airheads.”

The irony in the Iraq War is that the delay in moving to a massive air campaign, the absence of any details about the air campaign during the daily press briefings, and the fact that so many reporters were embedded with ground forces led to a near reversal and a media focus on ground power to the partial exclusion of the largely “invisible” air and missile war. As shown in chapter 4, however, U.S. ground operations could not possibly have moved at the speed they did without the massive air effort that was under way, while it is clear from chapter 9 that airpower could never have targeted and struck at Iraqi ground forces with anything like the impact it had on the course of the war the Iraqis had not had to maneuver to try to halt the advance of U.S. ground forces.

Time may provide a more exact picture of how much each element contributed to the outcome of the war. But the key lesson really seems to be that each advance in air capability also advances ground force capability and vice versa. Furthermore, even if one argues that the Iraq War shows that joint forces can rely on airpower to reduce the need for ground troops, the “peace” that has followed has again shown that both asymmetric conflicts and peacemaking eventually tend to be dominated by the need for ground forces. In fact, if one compares the relative weight of ground and air forces in the Iraq War with that of the Gulf War, the main lesson seems to be that it is the ability to tailor new joint mixes of ground-air-sea power to the needs of a particular campaign that proves to be decisive.

This not only is a lesson that US commanders have drawn from their experience during the war, but is one reflected in the British Ministry of Defense’s report on the lessons of the conflict and in ways which illustrate how important US progress in jointness can be to interoperability with its allies.[135]

> The overwhelming success of rapid, decisive operations in Iraq reflects the deployment of fast moving light forces, highly mobile armored capabilities and Close Air Support, which made use of near real-time situational awareness by day and by night. The US ability to combine land and air operations and support them from the sea and from friendly bases at very high tempo enabled the mix and impact of joint assets to be adjusted to operational need or events across the whole theatre of operations. This is likely to shape US doctrinal development and impact on potential partners.

> The implications of maintaining congruence with an accelerating US technological and doctrinal dominance need to be assessed and taken into account in future policy and planning assumptions.

Increased Tempo of Operations: Shock and Awe versus Precision and Focus

The Iraq War certainly had an element of "shock and awe." U.S. airpower may not have been applied in ways designed to maximize the psychological and political impact of U.S. air strikes. However, a combination of nationwide air and missile strikes and the speed and scale of the Coalition land advance certainly had a powerful psychological impact on Iraqi forces and the Iraqi regime. The regime clearly was never able to respond coherently to the Coalition attack—the shock of U.S. airpower led many Iraqi units to disintegrate or largely avoid combat, and the shock of the land advance and initial U.S. land operations in the greater Baghdad area helped lead to the collapse of any last efforts at urban warfare.

At the same time, the Coalition targeted with great restraint. As a result, it may be more accurate to describe the Coalition campaign as having employed a new strategy of "precision and focus." This aspect of the war was largely air-dominated. A combination of new IS&R assets, new precision weapons, and much better avionics allowed all-weather precision strike operations with excellent targeting, with an emphasis on "effects-based" strikes and careful limitation of collateral damage. Not only did the United States nearly ten times as many precision-guided weapons relative to unguided weapons as it had during the Gulf War; it was able to target them with far more focus and effect. As for sheer numbers, nearly 100 percent of the combat aircraft the United States deployed in the Iraq War carried precision weapons, versus some 15 percent of the aircraft in Desert Storm. The British made even more use of precision – 85% of the total air munitions used – which compares with only limited British use of precision during the Gulf War and 25% of the munitions Britain used during Kosovo.[136]

The Coalition fired some 19,948 precision-guided weapons in the less-than-four-weeks-long Iraq War versus 8,644 in the six-week Gulf War, and some 955 cruise missiles versus 300.[137] Unlike previous wars, the Iraq War also focused on defeating Iraqi ground forces rather than on a broad mix of strategic bombing, interdiction bombing, and close air support. According to one report, some 15,592, or 78 percent, of the weapons and aimpoints were chosen to provide direct support to some aspect of coalition ground forces.[138]

At the same time, land forces too had a new degree of precision and focus. The British essentially anchored the Coalition position in the south while the main U.S. forces advanced directly on Baghdad, fighting only those forces that directly opposed their advance. Rather than try to defeat the entire Iraqi force structure, or defeat the nation, U.S. armor concentrated on defeating the regime. At the same time, focused U.S., British, and Australian Special Operations Forces allowed the coalition to strike at selected targets in the west, the north, and many other areas in Iraq—often combining special operations on the ground with the ability to call in air support to provide heavy fire power.

Netcentric Warfare, IS&R Technology, Processing, Integration, and Near-Real-Time Information Flow and Targeting

As shown in chapter 5, many aspects of the C4I and IS&R systems used in the Iraq War reflected an evolution of past capabilities and problems. The Coalition applied such systems, however, in a form of joint warfare that had an unparalleled degree of near-real-time situational awareness that shortened the "kill chain" from targeting to strike, and the sensors-to-shooter gap from days to hours in the Gulf War to hours to minutes in the Iraq War.[139] At this point, there is no way to analyze the relative role of space, UAVs, fixed-wing aircraft, SIGINT, ELINT, imagery, Special Forces, and human intelligence in detail. It is clear, however, that the resulting mosaic of intelligence and senor data was far better than in the Gulf War, and was processed and disseminated far more quickly. The time-consuming and relatively rigid process of sortie planning and targeting that shaped the Air Traffic Order in the Gulf War was replaced with a far quicker and more responsive system.

One senior officer described this process as follows:

> All such offensive air operations, manned or unmanned, were coordinated with the USCENTCOM air component command headquarters. The types of targets were broad-ranging. Some of them were time-sensitive targets—where intelligence led the US to believe that a particular location was a valuable target. And so in a relatively brief period of time, particularly compared to the years past, the coalition was able to do the planning, get the missile loaded with its mission data, out of a submarine or—a British or American submarine or American ship—and down range and export on the target, or some rather more stationary and strategic targets, including missile defense facilities, to Republican Guard headquarters and some regime structures in and around Baghdad and all throughout the country.…I think his degraded ability to command and control his formations meant that those Republican Guard formations had very little situational awareness on the battlefield of where to maneuver to, which played right into the decisive lethality that both the ground and the air component were able to put on him.

Lt. Gen. David D. McKiernan, the commander of the Coalition Forces Land Component Command, described the role of such assets, and netcentric warfare, as follows:[140]

> Network-centric warfare is an idea, a concept, and a reality that has been around now for some years. And to give you a good example, much of the command and control that this regime executed for its military was done through fiber optic cable and repeater stations. Through very, very good intelligence, and targeting and execution, that capability was consistently degraded to the point where we think he really had very little ability to command and control tactical formations before we closed with him with ground formations. And that's a reflection of network-centric warfare, of knowing where to go in that command and control network to take it out or degrade it so that he loses his ability to command and control his formations.
>
> … the technology advances in our military today, compared to my experiences in Desert Storm, allowed me to talk via tactical satellite communications and other means across a battle space of hundreds of miles; to be able to conduct, when we need to, video teleconferences, where commanders can plot out where they're at and what decisions they need to do next; and all of that put together in a joint construct, where I could see where all the airframes were, where all the ships are, where my counterparts in the air and the maritime components can see where the ground formations are.
>
> When you put all that together, that allowed us to make decisions with situational awareness of where we were at, where the enemy was at, and our view of the terrain and the weather much, much faster than we ever could in the past and exponentially faster than our opponent could. So

> when you put all that together, it allowed us to make decisions and then execute those decisions faster than any opponent.

It is important to note, however, that many of the US commands supporting USCENTCOM remained focused on the needs of a single service, and that many of the improvements in jointness were the results of improvising new approaches, rather than the result of a solid, well established system for joint warfare. As one example, an Air Coordination Element, led by an Air Force major general supported by 18 airmen, was attached to the Army's operations staff so that there would be closer cooperation in providing close air support and liaison with the USCENTCOM command staff in Qatar and the Combined Air Operations Center (CAOC) in Saudi Arabia. The manning of the CAOC was also increased from 672 personnel before the war to 1,966 during the conflict. Seven other teams, headed by a general or colonel, were assigned to each of the land force commanders to similarly improve operations, planning, and liaison. Britain had liaison officers attached to various U.S. elements to improve interoperability.

The Broader Picture: The Need for An Integrated Common Operating Picture, Interoperability, and the Possible Need to Eliminate Service-Oriented Subordinate Commands in the Theater

These experiences raise broader questions about the need to restructure US command and control systems, and the possible need to restructure theater commands. . As General Franks has noted in his analysis of the lessons of the war, one key lesson of the war is the ability to exercise joint command over all the US services, and allied forces, at distances as great as 7,000 miles -- the approximate distance from the theater to the USCENTCOM headquarters in Florida and the US national command authority in Washington.

At a minimum, this requires the US to keep developing the best common operating picture (COP) possible, and to develop a truly integrated, user-friendly, tracking and command and control architecture that brings together the operations of all of the military services. It also requires the US to design this system for information sharing with the allies of the United States.[141]

The report on the lessons of the Iraq War by the British Ministry of Defense reinforces the importance of this kind of advances in command and control, as well as for the importance of interoperability:[142]

> The UK has a wide range of communications and information systems performing different functions. These were not all compatible with each other or with US systems, which led to interoperability difficulties. As a result, reliable, secure, timely and effective communication between all stakeholders could not be guaranteed.
>
> The concept of Network Enabled Capability (NEC), introduced in the SDR "New Chapter", involves the integration of sensors, weapons and decision-makers in order to deliver rapid, controlled and precise military effect. Shortening the time between targeting decisions and execution…is a prime example of this. Many new capabilities introduced through the UOR process in this operation were designed to improve the passage and exploitation of information as first steps in the development of NEC.

The British report also notes the value of the ability of UK and US special operations forces to track each other's locations, thus improving situational awareness at all levels of

VIII. LESSONS AFFECTING AIR, MISSILE, AND LAND–BASED AIR DEFENSE FORCES

While no set of lessons can be decoupled from the overall lessons regarding joint operations, there are a number of lessons that primarily affect air, missile, and air defense forces. These lessons reflect the fact that the Iraq War probably was the first major war in which airpower could strike with near-real-time precision at many key tactical targets. At the same time, they also reflect the fact that air and missile tactics and technology continue to advance at an extremely high rate, and that future wars are likely to see even more effective use of precision, time-sensitive targeting and the integration of air and missile power into joint operations.

Air Dominance

As has been discussed in previous chapters, much of the air battle was conducted before March 19, 2000. The US and Britain greatly intensified their attacks on Iraq's ground-based air defenses after November 2001, and began an active campaign to suppress them in the summer of 2002 called "Southern Focus" in order to prepare for the US and British invasion to come. The impact of this "war before the war" is indicated by the fact the allies flew 21,736 sorties, struck Iraqi air defense 349 targets, and fired 606 munitions, between June 2001 and March 19, 2003.[185]

Once the war began, the key missions for coalition air forces were to (1) neutralize the ability of the Iraqi government to command its forces, (2) establish control of the airspace over Iraq, (3) provide air support for Special Operations forces and the Army and Marine forces that would advance towards Baghdad, and to neutralize Iraq's forces of surface-to-surface missiles, and suspected caches of biological and chemical weapons. [186] The US, British, and Australian air forces had an unprecedented ability to execute these missions. The coalition's ability to paralyze Iraq's air force and the systematic suppression of Iraqi air defenses allowed coalition air forces to achieve nearly total air dominance shortly after the first air strikes on March 19—a level of air superiority it had never enjoyed in any previous major war.

The coalition allies employed some 1,800 aircraft to deliver approximately 20,000 strikes against Iraq, and no aircraft were lost to air-to-air combat in the process.[187] According to the USAF, seven aircraft were lost to Iraqi ground fire—one A-10, four AH-64s, and 2 AH-1Ws—although an additional F-15E and a UH-60 may also have been lost to such fire. This total is roughly half the number of aircraft lost to accidents and other non-combat causes. A total of 13 aircraft, including two fighters, were lost to other causes.[188] There were a total of 25 aircraft accidents: four serious Class A, five Class B, and 16 less serious Class C, and a total of 32 problems with near collisions or hazardous air traffic reports (HATRs).[189]

An analysis by Tom Cooper, the editor of the Air Combat Information Group, provides the following chronology of losses and damage during the course of the peak period of the fighting. This analysis is not official, but it seems accurate in indicating that accidents and friendly fire caused as much damage and as many losses as the Iraqi forces did.[190]

- 19 March:

- MH-53 Pave Low III, USAF; hard landing inside Iraq; helicopter destroyed, crew and passengers "self-recovered";
- AH-64, 11th Aviation Brigade, U.S. Army; hard landing inside Iraq; helicopter and crew recovered; non-combat related accident;
- CH-46, USMC; crashed in Kuwait, 12 KIA; non-combat related accident

- 20 March:
  - 2 Sea King ASaC.Mk.7s; NAS 849; collided, 7 KIA;
  - AH-64, 11th Aviation Brigade, U.S. Army; hard landing inside Iraq; helicopter and crew recovered; non-combat related accident
- 23 March:
  - Tornado GR.Mk.4 or GR.Mk.4A; shot down by U.S. Army PAC-3 Patriot SAM, 2 MIA
- 24 March:
  - AH-64D 99-5135, 11th Aviation Brigade (C Company, "Vampires," 1-227 Attack Helicopter Battalion, 1st Cavalry Division), U.S. Army; damaged by RPG-7 and landed in the field near Karbala, Iraq; crew captured;
  - AH-64D, 11th Aviation Brigade, U.S. Army; damaged by RPG-7 and SMAF; RTB, but probably w/o;
  - AH-64, 11th Aviation Brigade, U.S. Army, damaged by RPG-7 and SMAF; RTB
- 26 March:
  - Phoenix UAV, ZJ300, British Army; shot down near Basrah;
  - Phoenix UAV, ZJ393, British Army; shot down near Basrah
- 27 March:
  - RQ-1B Predator UAV, 95-014, USAF; shot down over Baghdad
- 29/30 March:
  - AH-64, unit unknown, U.S. Army; crashed in "brown-out" conditions, probably w/o; crew OK; non-combat related accident;
  - UH-60, U.S. Army; damaged by crashing AH-64; helicopter and crew fate unknown; non-combat related accident;
  - UH-60, U.S. Army; crashed in brown-out conditions; crew fate unknown; noncombat related accident;
  - OH-58 Kiowa Warrior, 11th Aviation Brigade, U.S. Army; damaged by SMAF;
  - OH-58 Kiowa Warrior, 11th Aviation Brigade, U.S. Army, damaged by SMAF
- 30 March:
  - UH-1N, HMLA-169/MAG-39, USMC; crashed in southern Iraq; 3 KIA;
  - S-3B, VS-38/CVW-2, USN; rolled off deck after landing aboard USS *Constellation*; crew recovered; non-combat related accident;
  - AH-64, 1-3rd Aviation Regiment, 3rd ID (Mech), U.S. Army; crashed in "brownout" conditions, w/o; crew… recovered; non-combat related accident
- 1 April:

- AV-8B, HMM-263 USMC; crashed during attempted landing aboard USS *Nassau;* pilot recovered; non-combat related accident;
- F-14A, VF-154/CVW-5, USN; crashed due to engine malfunction during strike against enemy positions in southern Iraq; crew recovered; non-combat related accident;

- 2 April:
  - UH-60A, B Company 2nd Battalion 3rd Aviation Regiment, U.S. Army; shot down by SMAF near Karbala; 6 KIA;
  - F/A-18C, CVW-5, USN; shot down by U.S. Army PAC-3 Patriot SAM over southern Iraq; pilot not listed MIA = probably recovered
- 4th April:
  - AH-1W, HMLA-267/MAG-39, 3rd Marine Aircraft Wing, USMC; crashed in southern Iraq; 2 KIA …; non-combat related accident;
  - Phoenix UAV ZJ402, British Army; shot down over Basrah;
  - Phoenix UAV ZJ417, British Army; shot down over Basrah
- 7 April:
  - F-15E, 336th FS/4th FW, USAF; shot down over Tikrit; crew MIA
- 8 April:
  - A-10A, 173rd FS/Miss. ANG, USAF; shot down by MANPAD over Baghdad; pilot recovered;
  - A-10A, USAF; heavily damaged by SMAF and MANPAD over Baghdad; aircraft and pilot… recovered;
  - CH-46E, USN; crashed in Eastern Mediterranean during VERTREP-operation for USS *Truman*; crew recovered.

The Iraqi Air force never flew, and the Iraqi land-based air defenses failed to protect Iraqi forces in the field and eventually could not even defend Baghdad against urban close air support strikes by Coalition forces.

What is uncertain is whether such a level of superiority can be achieved in the future. It may be possible with some developing countries, and even with nations with larger and more modern air forces that lack systems similar to the AWACS as well as a full range of specialized support and electronic warfare aircraft and modern IS&R and C4I assets. One great question will be the extent to which the deployment of advanced land-based air defense systems like the Russian S-300 and Patriot can offset the advantages of modern airpower.

Effects-Based Bombing: Fundamentally Changing the Effectiveness of Airpower While Limiting Civilian Casualties and Collateral Damage

Despite the problems in U.S. and allied IS&R and targeting capabilities described in previous chapters, improvements in these areas did allow the Coalition to use a new approach to targeting. This approach is called “effects-based” bombing and involves the selective use of precision airpower to strike at targets to produce effects rather than simply maximize physical damage.[191] Examples of such targeting include knocking out power, communications, and fuel supplies to Iraq military forces, rather than attacking major infrastructure facilities. Others include selectively bombing Iraqi regular army forces to paralyze or reduce their movement rather than destroy them by attrition, and using sensor platforms like the E-8C JSTARS to attack actual military units in movement, rather than blow bridges and attack lines of communication.

Improved avionics and precision greatly reduced the need for multiple weapons to be used on a given target and for later restrikes. As one senior Air Force general put it, "Even in the Gulf War, the issue was always how many sorties it took to destroy a given target. In this war the issue is how many targets can be destroyed in a given sortie." Advances in precision also allowed the United States to reshape its targeting and choice of munitions to reduce civilian casualties and collateral damage. One irony behind the increased lethality of modern weapons and tactics is that they can be used to defeat the enemy with far fewer secondary costs. Improvements in laser-guided systems and the use of GPS allowed the use of smaller bombs and often allowed 500-pound bombs to be used instead of 2,000-pound bombs.

The United States made use of new targeting aids like the "bugsplat" program.[192] This allowed it to choose the munitions and angle of attack that could destroy the target to the point necessary to produce the desired effect, but to do so using the smallest munition and the angle and point of attack that would produce minimal risk to civilians and collateral damage.[193]

True Precision Air Strike Capability

While no battle damage data are publicly available, and reliable battle damage data may never be available, it is clear from the previous history of the war that the evolution of precision air strike technology greatly improved Coalition capabilities in carrying out these strikes. Even in the Gulf War, only a small number of aircraft like the F-117, F-111, and F-15E were properly equipped for advanced precision strike missions. In the Iraq War, virtually all U.S. aircraft had the avionics necessary to make use of a wide variety of precision weapons by acquiring targets, illuminating them when necessary, using GPS guidance, and acquiring targeting coordinates from the ground. To put these differences in perspective, only one out of five strike aircraft could launch laser-guided bombs in the Gulf War; all strike aircraft could launch laser-guided bombs in the Iraq War.[200]

The onboard sensors and computer systems on these aircraft were much more capable both in executing preplanned strikes and in the dynamics of acquiring and killing. The integration of intelligence assets into target planning and the speed of execution made precision strikes more effective. All-weather coverage was better, and while the term "all-weather" will probably always seem at least somewhat ironic in air combat, field reports so far indicate that it was a far more realistic description in the Iraq War than in previous conflicts.

A combination of UAVs and better sensor aircraft, systems like the E-8C, and improved infrared and radar sensors interacted with better command and control to allow the effective use of both better delivery platforms and better precision weapons. For example, experimental use was made of the E-8C JSTARS to target Iraqi armor even under sandstorm conditions. Dust and sand did present problems in some cases. Still, the widespread dissemination of laser illuminators to ground forces and SOF units allowed them to call in precision close air support, as did giving them GPS targeting capability.

Understanding the True Meaning of Precision

This does not mean that the air and missile campaign achieved anything approaching "perfect war." Detailed BDA data are lacking, but enough pilot and post-strike reports are available to show that precision is still relative despite all of these advances. The U.S. and British briefings shown during the war provided television footage of weapons that virtually all hit the correct target. In practice, however, there are still major problems in the IS&R effort, and significant numbers of targets were mischaracterized.

The British Ministry of Defense report on the lessons of the war describes the following range of issues involving targeting:[201]

> Planning for the air campaign included the development of a list of potential targets that would help the coalition to achieve its overall objectives. Over 900 potential target areas were identified in advance. All targets were derived from the campaign plan and were selected to achieve a particular military effect (such as the degradation of Iraqi command and control systems). Operating within parameters agreed by Ministers, Commanders taking targeting decisions had legal advice available to them at all times during the conflict and were aware of the need to comply with international humanitarian law, the core principles of which are that only military objectives**1** may be attacked, and that no attack should be carried out if any expected incidental civilian harm (loss of life, injury or damage) would be excessive in relation to the concrete and direct military advantage expected from the attack. Extensive scientific support including detailed computer modeling was used in assessing potential targets. Strong coordination between the MOD, the Permanent Joint Headquarters (PJHQ) at Northwood and the in-theatre National Contingent Command helped ensure coherent target planning (a lesson from previous operations). The Department for International Development was also consulted on key humanitarian infrastructure issues. The process for approving all targets for UK aircraft,
>
> Targeting for submarine-launched cruise missiles or for coalition aircraft using UK facilities was conducted with appropriate political, legal and military oversight at all levels. We also influenced the selection and approval of other coalition targets.
>
> … The campaign also showed that coalition aircraft needed to be able to identify and target mobile, camouflaged and underground assets and facilities and to achieve discrimination in urban areas. This requires improvements in data transfer, tactical reconnaissance and high definition imagery systems to deliver shorter sensor to shooter times for time-sensitive and 'find and destroy' missions. The operation also highlighted that the integration of Close Air Support aircraft requires further refinement and practice. It demonstrated the advantages of multi-role aircraft and long-range, high payload platforms. Unmanned Aerial Vehicles have the potential to play an increasing role in the joint battle, both for surveillance and strike and may offer opportunities against time sensitive targets.
>
> …Future targeting work will concentrate on improving precision and reducing the time taken to guide weapons on to targets including weapons fired from the sea and long-range, indirect land systems.

It is also important to note that the accuracy of precision weapons quoted in most technical sources is based on the average distance from the target hit by 50 percent of the weapons fired—assuming a perfect target location, a perfect launch, and perfect functioning of the weapons system through the final guidance phase. In the real world, this means that roughly half of the weapons fired are less accurate, but there is no statistical definition of their accuracy of the other half of the weapons fired.. Data on the real-world average performance of weapons under operational conditions are sometimes available, but are generally classified.[202] Moreover, the combination of perfect targeting, perfect launch, and perfectly functioning weapons assumed in producing such accuracy data is rarely possible.

The United States and its allies compensated for this reality by establishing rules of engagement that sought to prevent the launch of weapons under uncertain conditions, particularly when they might produce collateral damage. Nevertheless, "precision" did not mean that many weapons were not fired at the wrong target, or selected in ways where the munition had the wrong effect, or launched under the wrong conditions, and/or that they did not fail in some way in flight. There also are enough pilot and combat reports to show that major failures of the control surfaces on guided weapons sometimes resulted in the weapon striking far from its intended target, regardless of the target coordinates used to launch the weapon and the potential accuracy of its guidance system. To put this in perspective, it often took several weapons to achieve a kill or the required level of damage—rather than the one kill per weapon generally shown in official briefings.

Yet, it is also clear that the real-world targeting, launch, and weapons performance of precision weapons was generally much more accurate than it had been in Kosovo or the Gulf War. It is also important to note that briefings and battle damage assessment tend to focus on achieving catastrophic damage or enduring functional kills of the target. The Coalition often did achieve these effects, but they are only part of the impact of precision warfare.

The psychological impact of near misses and of watching precision kills on other nearby targets is extremely high. It is quite clear from postwar Iraqi accounts that it is not necessary to achieve the desired degree of damage to have forces evacuate a building or desert their equipment. Moreover, the high levels of attrition sometimes claimed against targets like the major weaponry in Republic Guard units—50 percent, 70 percent, and even 90 percent—are scarcely necessary to force the disintegration of the unit as a functioning warfighting entity. Losses of only 15-20 percent have been enough to achieve such results in previous wars, although the level of damage required varied sharply by military force and unit. The fact that BDA cannot quantify the impact of precision on morale, desertions, and the willingness to fight does not mean that even "misses" are not of vast importance in terms of their real-world military effects.

Stealth

Both the B-2 and F-117 played an important role in the Iraq War, although the value of stealth per se remains uncertain. For example, the 12 F-117 stealth strike fighters based at Al Udeid Air Base in Qatar flew 80 of the roughly 17,000–20,000 sorties classified as strike missions. While the numbers were limited, all of those missions were against heavily defended targets in the greater Baghdad area and struck at key targets like the air defenses, important headquarters, and radio relay stations.[218]

For the first time, these missions were able to use GPS-guided weapons. Unlike the laser-guided weapons used in the first Gulf War, the GPS-guided weapons could not be obscured by clouds or smoke.[219] Problems still emerged because of the long time needed to enter targets into the ATO. But the use of time-sensitive targeting and kill boxes allowed Iraqi forces to be targeted at the last moment, greatly cutting down on the "kill cycle" in the Gulf War and also freeing the pilot to concentrate on the mission.

This rapid decision cycle also allowed the F-117 strikes to be coordinated with the cruise missile strikes launched against Saddam Hussein and the Iraqi leadership on the first night of the war—as well as rapid arming with EGBU-27s that had just arrived in theater the day before, and planning support sorties from F-16CJ anti-radar fighters, EA-6B electronic warfare aircraft, and KC-135 tankers.[220] About one-third of the F-117 missions came in the first three days of the war, when Iraqi air defenses were most effective. One interesting aspect of their missions is that a shortage of refueling tankers forced two-thirds of the F-117 missions flown during the first major night of strikes to cancel their mission before they launched their weaponsThis is another demonstration of the value of range-payload in bombers like the B-2 or in new stealth-like aircraft like the FB-22.[221]

At the same time, cost remains a critical issue. Whatever the potential value of stealth aircraft, they are extremely expensive and have a long history of escalating in procurement and operating costs. The F-16 also proved to be highly effective in the Iraq War, as did the A-10 within its mission limitations. The F/A-22 Raptor has increased in cost by 128 percent since its development started in 1986, and the GAO claims the program has encountered some $20 billion in overruns. The planned buy of the F/A-22 has shrunk from 750 aircraft to around 276, and the procurement cost of the smaller number has risen to $42.2 billion in spite of a congressionally imposed ceiling in 1998 of $36.8 billion.[222]

This experience is not that unusual for a new major weapons system. It illustrates, however, the broader risks in force transformation touched upon in chapter 5. At the same time, the F-16 is largely a sunk cost and the more advanced models have recently had a unit cost of roughly $38 million—somewhat similar to the cost of the late model production runs of the F-15. In contrast, the current Air Force estimate of the unit cost of the F/A-22 is $133.6 million and the GAO puts the cost at over $200 million. The new Joint Strike Fighter, or F-35, also has some stealth features and an estimated unit cost of between $37 million and $47 million, and the U.S. Navy is seeking to buy some 548 F/A-18 E/F Super Hornets.[223]

Like many other possible "lessons" of the Iraq War, these facts show the danger of generalizing from combat experience without explicitly analyzing cost-benefit and cost-risk, the value of alternative uses of money, and the risks inherent in giving up current force capability or force numbers for as yet unproven and uncostable systems.

Close Air Support

In spite of all the progress the US and Britain made in jointness, both forces still believe significant improvements can be made in organizing and supporting the close air support mission, and in training for this mission. For example, the British Ministry of Defense concluded that, "The operation…highlighted that the integration of Close Air Support aircraft requires further refinement and practice."[224]

This message has been reinforced by a recent study by the General Accounting Office, although the study preceded the Iraq War. The study found that troops were not properly trained for close air support, and that the USAF continued to focus more on longer-range interdiction missions. It also found that a joint interservice steering committee still have made only limited progress in standardizing procedures and equipment.[225] Both British and Australian officers report a similar need to standardize if forces are to be properly interoperable.

One key challenge is to integrate fixed wing, attack helicopter, artillery, and land-based air defense operations. The US seems to have done much better in the Iraq War – partly as a result of lessons learned from Operation Anaconda in the Afghan War – but much of this improved was improvised on an ad hoc basis and much can still be done. It is also clear from the Iraq War that every advance in IS&R, communications systems, and digital management of the battlefield both increase the capability to carry out close air support and the need for tighter integration, better training, and more standardized procedures and equipment.

Urban Close Air Support Is a Reality—Under the Right Conditions

The United States conclusively showed that modern air power can target and strike even in cities with great effect and minimal collateral damage.[226] The United States effectively set up urban "kill boxes" over Baghdad with strike aircraft on 24/7 patrols **armed** with a variety of munitions. It used a variety of UAVs for surveillance and targeting, including the Predator and high-flying Global Hawk. This allowed strikes to be called in with munitions suited to the precision and warhead size needed for such attacks.

The use of 500-pound bombs and cement bombs reduced collateral damage in strikes on "sensitive" targets near civilians or key civilian facilities. Bombers provided the endurance and high payloads necessary to ensure rapid response and the ability to deliver multiple strikes. Close air support aircraft and attack helicopters like the A-10, Harrier, and AH-1W provided low-altitude coverage over both Baghdad and Basra, and could provide better angles of attack using weapons like Hellfire and TOW and could also strike with lower-yield weapons that inflicted less collateral damage.[227]

New Fuses on "bunker buster" weapons like the GBU-27 and GBU-28 ensured that the weapons exploded underground. Having men on the ground illuminate and verify targets helped. It is not clear how pure kinetic weapons were used, if at all, but accuracy has improved to the point where a cement warhead can be used to demolish key walls and barriers.

At the same time, the war did expose limits. The Coalition was able to move key aircraft forward, such as tankers and the E-8C JSTARS, only because it had gone far beyond air superiority to air dominance. This also allowed it to use aircraft like the A-10 in low-attitude strafing runs at 2,000–3,000 feet and to keep "stacks" of different aircraft with different mixes of munitions safely on call near the greater Baghdad area.

The Coalition found that its initial targeting constraints and rules of engagement were too restrictive. They sometimes forced restrikes or failed to accomplish their mission, forcing additional combat without reducing collateral damage. As a result, the Coalition increased the intensity and concentration of some types of strikes against urban targets, inevitably increasing collateral damage.[228]

Many air munitions could not be used in areas with buildings closely placed together because they could not be launched with the proper angle of attack. In several cases, a target could be attacked only if ground troops were present to illuminate it, but the troops could not remain in the conflict area long enough to allow the aircraft to come in or the laser could not be read because of urban dust and complex visual angles. More flexible munitions may be needed, along with systems like robotic reconnaissance and illuminators to allow ground troops to conduct targeting without being exposed to combat.

The Value of Expeditionary Air Power and Problems in Allied Readiness, Interoperability, and Modernization

The U.S. military has long recognized the need for expeditionary air power. Carriers provide it by definition, all Marine Corps aviation is expeditionary, the U.S. Army is increasingly making its helicopter forces expeditionary, and the U.S. Air Force has steadily converted to a lighter posture and one where power is easier to project. As a result, the USAF has divided its aircraft into 10 sets called Air Expeditionary Forces (AEFs) that are designed to deliver a full mission-capable mix of aircraft in pairs of AEFs that can be deployed for 90 days. Four full AEFs were sent to the war in Iraq, along with parts of four others. In addition, the USAF has worked with the U.S. Navy to develop synergistic packages where scarce special purpose aircraft with similar functions—such as the RC-135 and EP-3—can either reinforce or replace each other. The U.S. Navy and Marine Corps, in turn, are developing a Fleet Response Concept to allow U.S. Navy and Marine Corps aircraft to deploy more quickly and in greater numbers, to allow carriers to stay longer on station by rotating crews, to use amphibious ships as light carriers, and to improve Marine Corps aviation capability to act as an expeditionary force off ship.[229]

During the Iraq War, USAF Expeditionary Combat Support ECS) was critical to U.S. success. USAF ECS units built and supported 12 new bases (including 5 in Iraq) while expanding capabilities at 10 established sites. At the same time, they maintained, loaded, and launched the Combined Forces Air Component Commander's air force.

During the actual operation, ECS units—

- launched more than 46,000 sorties with a maintenance effectiveness rate of 98 percent;
- issued more than 1 million gallons of JP-8 per day (five times the typical rate) at three bases in the region, with a high at one base of 1.8 million gallons in one day;
- offloaded 344 different munitions commodities from ships and strategic airlifters with no sorties lost to weapons availability and 21.5 million pounds of ammunition delivered;
- served more than 111,000 hot meals each day and positioned 2.7 million MREs in support of combat operations in and around Iraq;
- positioned 91,000 JSLIST chemical warfare suits, 2,100 gas masks, 1,000 flak vests. and 7,200 weapons in-theater to outfit the force after unit reporting instructions changed on the fly;

- formed the “Red Tail” express with leased Kuwaiti trucks to transport CFACC combat power deep into Iraq when the need outpaced the availability of coalition trucks;
- ensured combat readiness at one location by contracting for bare-base support, including site preparation, building the large expeditionary shelters, and putting up billeting tents for 375; and
- made purchases off the Iraqi economy to support deployed forces during ongoing combat operations.

The ability of Special Forces, the U.S. Army, the U.S. Marine Corps, and the U.S. Air Force to rapidly restore airfields or create ones large enough for C-130 operations was another important aspect of expeditionary airpower. So was the ability of the C-130 and C-17 to operate off of short and unimproved runways.[230]

The British Royal Air Force converted to a far more effective expeditionary posture between 1990 and 2003. It was able to rapidly adapt basing and support plans focused on deployment to Turkey to allow operations in the Gulf. Like similar changes in the USAF and U.S. Marine Corps to support more rapid forward basing and expeditionary operations, the RAF demonstrated that effective power projection planning and equipment are a critical part of effective airpower. It also was able to help the U.S. Navy because RAF tankers use refueling drogues, rather than a piloted boom, and can refuel U.S. Navy aircraft—an example of allied interoperability that helped the United States.

The RAF also moved away from an outdated reliance on low-altitude penetration using unguided weapons in 1991 to the use of precision-guided weapons and aircraft with avionics capable of targeting and firing such weapons (rather than needing to bring in Buccaneers to illuminate the target for Tornadoes), and it introduced new weapons like the Storm Shadow stand-off cruise missile, which has a range of up to 300 nautical miles.[231] Britain also introduced the use of the Enhanced Paveway II GPS-guided bomb and Maverick AGM-65 by its Harrier G7 attack aircraft, and it made use of the Enhanced Paveway II and III GPS-guided bomb on its Tornadoes.

The British Ministry of Defense cited the success of this expeditionary approach to airpower as one of the lessons of the war.[232] It also recommended that, “Further investment is required in Expeditionary Campaign Infrastructure, Temporary Deployable Accommodation and personal equipment, which should be designed to support expeditionary air operations.[233]

Although the Royal Australian Air Force provided only a limited number of aircraft, it too demonstrated the value of designing an air force for power projection and tailoring combat aircraft for interoperability with larger air forces like those of the United States. Australia had learned from deployments during the Gulf War, East Timor, and Afghanistan, and it had acquired new aerial refueling tankers, Airborne Early Warning and Control (AEW&C) aircraft, improved air-to-air missiles, and standoff air-to-surface weapons. It had also upgraded the avionics on its F-18 fighters to make them interoperable with U.S. and British forces by taking steps like replacing their APG-65 radars and fire control systems with APG-73s.

There is, however, a much grimmer lesson here for most European air forces, as well as for NATO and the European Union. There is no “western” advantage in airpower. Most European air forces lack sustainability, modern technology, and effective readiness and training. Most also lack the capability either to act as independent expeditionary air forces or to be fully interoperable with the United States. To be blunt, their civilian masters have allowed them to decay into aging, heavily bureaucratic forces that often modernize in ways better suited to the politics of the European defense industry than to effective warfighting.

There are good reasons why most European governments furnish virtually no meaningful transparency into the readiness of their air forces and the effectiveness of their modernization plans. In most cases, their five-year plans are simply a cosmetic façade hiding a steady decay in force strength and/or readiness and drift toward high-cost technological obsolescence. This is not helped by NATO and EU force plans that similarly paper over real-world problems, set meaningless or unmet goals, and are triumphs of institution building over military reality.

Changes in Air Combat Packages

No data have been published on the kind of mixes or “packages” of different aircraft types the United States and Britain assembled to carry out given missions in the Iraq War. It is clear, however, that substantially fewer air defense and electronic warfare escorts were needed and that the number of electronic intelligence aircraft dedicated to given packages could be reduced because of superior netting, intelligence platforms, and multipurpose aircraft. On the other hand, there are some indications that the number of refueling missions went up because Coalition aircraft had fewer bases near Kuwait, flew longer mission distances, and loitered longer.

Hard Target Kill Capabilities

It will take some time before the United States and Britain can clearly evaluate the effectiveness of their attacks on hard targets and deep underground shelters. At least one preliminary report indicates, however, that the United States failed at least sometimes to kill critical underground facilities. A reporter who walked through one shelter in Saddam Hussein’s Abu Ghurayb Palace produced the following report:[234]

> The bunker, toured several days later by a reporter, withstood the palace's destruction by at least two satellite-guided bombs. The bombs left six-foot holes in the reinforced concrete palace roof, driving the steel reinforcing rods downward in a pattern that resembled tentacles. The subsequent detonation turned great marble rooms into rubble. But the bunker, tunneled deep below a ground-floor kitchen, remained unscathed. The tunnel dropped straight down and then leveled to horizontal, forming corridors that extend most of the breadth of the palace. Richly decorated living quarters were arranged along a series of L-shaped bends, each protected by three angled blast doors. The doors weighed perhaps a ton. In a climate-control room, chemical weapons filters and carbon dioxide scrubbers protected the air and an overpressure blast valve stood ready to vent the lethal shock waves of an explosion. And a decontamination shower stood under an alarm panel designed to flash the message "Gas-Gaz."

Other reports raise more serious issues. At least some of the targeting assumed the existence of bunkers or tunnels that did not actually exist.[235] This proved to be true, for example, of the attack on a supposed bunker in the Dora Farms area near Baghdad on the first night of the war. It was this “bunker” that coalition planners hit in an effort to kill

Saddam Hussein and other top members of the Iraqi leadership. In practice, the information proved to be from an inaccurate Iraqi source, and postwar examination showed that there was no bunker at the site.[236] More generally, discussions with U.S. targeteers and analysts indicate that despite more than a decade of intense analysis, the United States still has no clear basis for estimating what was in most hard and soft shelters, whether they had been evacuated before the war began, and what the effect of destroying or damaging the building or facility was on Iraqi warfighting capability. In this sense, "effects-based bombing" usually is limited by the fact the United States cannot see into a black box either on the surface or underground.

In short, the hard target problem is not simply one of hard target kill, but one of hard target characterization. This involves the existence of the target, its physical nature, its function, whether it is actually occupied and used in wartime, and the effect of any given level of damage. This is a critical problem both in IS&R terms and in the ability to implement a full range of effects-based and netcentric operations. It is also an important caveat regarding the use of very large conventional or small nuclear weapons to kill hard targets. The issue is not simply one of ensuring that the target can be destroyed; it is ensuring whether the target exists and should be destroyed at all.

The problem is also certain to grow with time. While U.S. and allied IS&R coverage is increasing in scope and persistence, the ability of developing countries to create closed structures and then create hardened facilities in or near those structures in ways that are not detectable by imagery is also growing. So is the understanding of both governments and extremist groups that rapid dispersal, the creation of covert dispersal facilities, and the exploitation of natural features like caves present major challenges in terms of both targeting and physical attack.

Cruise Missiles

The United States used a total of 153 bomb-launched CALCMs and 802 BGM-109 TLAM Tomahawk sea-launched cruise missiles in the Iraq War. These cruise missiles proved far more effective in the Iraq War than in the Gulf War, in large part because the addition of GPS guidance and improved reliability allowed them to be much more accurate and to fly a much wider range of attack profiles. The operational range of the system also increased from "500 miles plus" to "more than 1,000 miles," and missiles could be programmed in hours rather than over a period of three days.[237] At the same time, the relatively small warhead size of the Tomahawk limits the range of targets it can attack, and the performance of the CALCM, with a heavier warhead and hard target penetrator option, remains uncertain.

The CALCM has a nominal range of around 600 nautical miles and flies at high subsonic speeds. Some estimates put its warhead at 1,500–2,000 pounds. Other sources put it at 3,000 pounds. Two versions seem to have been used in the Iraq War.

- The Block IA CALCM uses a third-generation GPS receiver along with advanced navigation software and a GPS anti-jam electronics module and antenna for a significant increase in jamming immunity. To increase its effectiveness against a wider spectrum of targets, it has a capability for shallow to near-vertical dive angles from any approach reference point. Flight software improvements include a large-state Kalman filter for optimizing GPS accuracy, including code and phase measurement data, pressure and temperature measurements, and wide-area GPS enhancement to reduce system errors.[238]

- The AGM-86D Block II program is the Precision Strike variant of the CALCM. It incorporates a penetrating warhead, an advanced guidance package coupling GPS and inertial guidance, and a modified terminal area flight profile to maximize the effectiveness of the warhead. The penetrating warhead is augmented with two forward shaped charges. To maximize the warhead's effectiveness against hardened targets, the Block II will maneuver and dive onto its target in a near-vertical orientation. The updated guidance system is supposed to have obtained a less than 5 meter CEP.

The Navy's BGM-109 Tomahawk Land Attack Missile, or TLAM, cruise missile also demonstrated a steadily increasing accuracy, reliability, and lethality. It now combines jam-resistant GPS guidance with its earlier terrain contour matching (TERCOM) radar guidance that compares a stored radar map against the radar signature of the terrain to navigate and optical Digital Scene Matching Area Correlation (DSMAC) to home in on its target by comparing the image to the actual target. The GPS guidance allows the Block III and later version of the TLAM to fly a wide range of attack profiles, making its direction of attack less predictable, and the system can be programmed more quickly. Its improved performance was first demonstrated in Bosnia in 1995, and then demonstrated in depth during some 70 attacks on Taliban and al Qaeda targets in the Afghan conflict in 2001. The BGM-109 Block III has both unitary and cluster warheads with combined effect submunitions. Its nominal payload is 1,000 pounds. Its speed is about 550 miles per hour and its range is about 600 nautical miles.

Thirty-five of the 140 vessels the U.S. Navy had in the Persian Gulf, Red Sea, and Mediterranean were capable of firing the missile. They had a total inventory of roughly 1,500 missiles, and approximately 800 were fired. Vice Admiral Timothy Keating, commander of all maritime forces involved in Operation Iraqi Freedom, described the role of cruise missiles as follows in a briefing on April 12, 2003:

> Since we began Operation Iraqi Freedom on the 19th of March, United States and United Kingdom ships have fired over 800 Tomahawk missiles in support of General Franks' campaign. Sailors and ships… we coordinate all those targets with the Air Force. As I think you all talked last week with General Buzz Moseley, he is the air component commander, and so all offensive air operations, manned or unmanned, are coordinated with—through Buzz Moseley's targeting shops. So, any target that we're assigned and told to prosecute, that is vetted with Buzz Moseley's air component command headquarters.
>
> "The types of targets were broad-ranging. Some of them were time-sensitive targets—that is to say that we had intelligence that led us to believe that this particular location was a valuable target. And so in a relatively brief period of time, particularly compared to the years past, we were able to do the planning, get the missile loaded with its mission data, out of a submarine or—a British or American submarine or American ship—and down range and export on the target, or some rather more stationary and strategic targets, including missile defense facilities, to Republican Guard headquarters, and some regime structures in and around Baghdad and all throughout the country.
>
> "… when TLAM were first introduced into the Navy arsenal, it was a matter of not hours, not even days, but several days for all of the planning to take place. And so it took quite a while from determination of target, through mission planning, to prosecution of the targets. These days it can be measured in hours, due principally to—well, one reason, we have better computers these days.

> Another reason, more important, we have smarter kids doing it these days. And third, the fusion of intelligence and operations and our ability to communicate over secure lines worldwide. All of those factors contribute to a dramatic reduction in the time required from determination that's the target we want to hit to Tomahawk impacting the target.
>
> "…You know, as do I, that a few of our missiles have been found in Turkey and Saudi Arabia. We've shot over 800 and we've found less than 10 in—that didn't get to the target, if you will. That is a very low percentage, as you no doubt—1- over-80, what's that .1—1.25 percent. As for the effectiveness of those Tomahawks and the effectiveness of each individual piece of ordnance, I couldn't tell you right now, but I would say, hazarding a guess, that the dramatic success that General Franks and everybody working for him that we've enjoyed is likely due to our ability to prosecute specific targets throughout the entire country of Iraq, and again, prosecuting with remarkable, in our view, remarkable flexibility and this very pinpoint precision so as to be able to, in the aggregate go very quickly around areas where we didn't want to fight or didn't need to fight and get to the heart of the Iraqi regime leadership and topple that leadership in very short order."

The claimed failure rate for the Tomahawk cruise missile in the Iraq War was about 2 percent as opposed to more than five times that percentage in the Gulf War. The 800 missiles launched compares to 288 in 1991. The time for targeting at the CAOC was reduced to hours and sometimes minutes in comparison with an average of several days during the Gulf War.[239] For the first time, U.S. command and control could also closely coordinate air and cruise missile strikes, as it did in the attack on Saddam Hussein and the Iraqi leadership on March 19.

At the same time, the cost of some 800 missiles approaches $500 million to $1 billion—depending on the costing method used; the U.S. Navy budgets some $600,000 per missile, but the Congress still appropriates roughly $1 million.[240] Some missiles also went off course in politically embarrassing ways over countries like Saudi Arabia and affected U.S. overflight rights. The need to cost-engineer cruise missiles to much lower prices and find some form of self-destruct remains a lesson of this war, as it has in every war since the Gulf War.

The Bomber and the Advantage of Range-Payload

The Iraq War will eventually produce detailed lessons for virtually every aircraft used in it, just as it will for virtually every other land or air system. In the case of aircraft, initial pilot reports make clear that virtually every attack fighter benefited from the improvements in sensors, avionics, and precision-guided weapons delivery capability. This affects the A-10, AV-8B, F-14, F-15, F-16, F-18, and Harrier, as well as future designs. Some of these lessons are discussed throughout this book. Many, however, require detailed operations analysis that may take a year or more to complete.

The Continuing Role of the Bomber

Among the general lessons that are already available, the changes in the role of the bomber are particularly striking. As in the Afghan War, the B-1, B-2, and B-52 all demonstrated the value of the bomber as a precision strike system with stealth penetration or stand-off delivery capability to hit large numbers of aim points or targets with precision weapons in a single sortie. The B-2B stealth bomber, for example, had the capacity to carry 16 2,000-pound bombs like the JDAM or up to 70 500-pound guided bombs on a single sortie and fire each at a separate target.

The B-52 and B-1B could also carry large numbers of precision weapons like the JDAM, as well as use the Wind Corrected Munitions Dispenser and strike at different targets on each sortie, The use of precision-guided weapons allowed these bombers to strike from outside the range of all but the most heavily defended areas, and the steady upgrading of their electronic warfare capabilities improved their survivability. One press report indicates that the B-52 and B-1B delivered two-thirds of the bombs dropped during the war; another credits the B-1B alone with dropping half of the JDAMs. These numbers may well be exaggerated, but there is no doubt that these legacy systems played the same kind of critical role in terms of total tonnage dropped that they did in Afghanistan.[255]

The B-52 was the long-established workhorse of the U.S. bomber fleet. The USAF showed that a bomber as old as the B-52 could be given new life by improving its precision-guided weapons targeting and launch capabilities like the LITENING forward-looking targeting pod, its electronic countermeasures, capability to retarget in mid-flight, and reengining.[256]

USCENTCOM estimates that bombers flew roughly 555 sorties between March 19 and May 1, with the B-2 flying 50 combat sorties, the B-1B flying 225 sorties, and the B-52 flying 280. This was only 1.7 percent of the 32,850 USAF sorties flown during this period. USCENTCOM also estimates that fighters flew some 17 times more sorties than bombers. The B-1 and B-52, however, delivered a surprisingly high percentage of the total tonnage and precision-guided weapons delivered, and many of these strikes were flown against time-sensitive targets. In many ways, this repeated the experience of bombers in Operation Enduring Freedom in Afghanistan, where bombers flew only 20 percent of the sorties in the first three weeks of the fighting but delivered more than 76 percent of the tonnage.[257]

The Impact of the B-1B Lancer

The B-1B's mission readiness rate had improved strikingly in the year before the Iraq War, in part because one-third of the fleet had been deactivated in August 2001 to allow the remaining bombers to improve their readiness rates and reduce "cannibalization" in the form of taking parts from other aircraft. The B-1B had not flown in the first Gulf War because it could not carry precision-guided weapons. Giving it such a capability after the war allowed it to fly 74 sorties during Operation Allied Force in Kosovo. Eight B-1Bs were deployed to support operations in Afghanistan.[258] According to press reports, they flew only 5 percent of the sorties during the first three weeks of the Afghanistan war, but delivered 28 percent of the tonnage and ultimately delivered nearly two-thirds of the total number of JDAMs used in the conflict.[259]

In the Iraq War, reports indicate that the B-1B flew only 2 percent of the total sorties but dropped as much as 44 percent of all JDAMs. One press report indicates that B-1 bombers flew 6–7 sorties a day and delivered a total of more than 2,100 bombs and a payload of more than 4 million pounds. Another indicates that the B-1B and B-52 combined flew more than 432 sorties and delivered more than 2,250 tons of bombs. Each B-1B could carry 24 1-ton weapons, and most used a mix of bombs fused to delay for 25 milliseconds to penetrate their targets and to explode on contact. The aircraft could loiter for up to 8 hours over the battlefield, with refueling. In one strike on April 7, for example, a B-1B was called in to deliver four weapons against a site near a restaurant in downtown Baghdad where Saddam and his sons were thought to be meeting and then went on to hit 15 additional targets (6 in Baghdad and 9 in Tikrit).[260]

The Future Mix of B-1Bs and B-52s

The United States does not have enough B-1s to equip its 10 air expeditionary forces, and the USAF must use a mix of six B-1s and six B-52s for each force. This helps explain the continued upgrading of the B-52. Similar upgrading is taking place with the B-1B. There are 67–69 B-1s available, and virtually all of the 96 remaining B-1s would have to be operational to rely on the B-1. The USAF is also considering providing full Link 16 and Fully Integrated Data Links to transmit more complicated targeting and command and control data digitally to the aircraft. At present, all four crew must verify voice signals.

Other possible upgrades include providing a more reliable communications link to ground forces to eliminate a problem in communications when the B-1B is banking or turning. Another is improving the resolution of the radar from 10 feet to one foot, providing cheaper and more effective electronic countermeasures, and adding a forward-looking infrared system to provide better night and laser-guided bomb targeting such as the LITENING II pod being installed on some B-52s. Equipping the aircraft to use the 250-pound smart bomb would also allow its revolving launcher to carry between 96 and 144 guided weapons.[261]

The Impact of Range-Payload on Fighter Attack Aircraft and the F/A-18E/F

High-range payload fighter-attack aircraft like the F-15, F-16, F-18, and Tornado demonstrated a similar capability to make far more effective use of airpower. The ability to retarget aircraft to use precision weapons on an on-call basis demonstrated the value of range-payload in increasing loiter time as well. So did the F-16C/D, which had had a massive upgrade in its avionics and capability to deliver precision guided weapons since the Gulf War, and had a far greater range-payload than the original F-16A/B The improved IR sensors in a number of U.S. strike attack fighters allowed them to target Iraqi armor far more effectively than in the past, sometimes in dust storms.

The United States also made combat use of the new F/A-18EF Super Hornet for the first time. The F/A-18E/F aircraft are 4.2 feet longer than the F/A-18C/D. They have a 25 percent larger wing area and carry 33 percent more internal fuel. This increases their mission range by 41 percent and endurance by 50 percent. The nominal mission radius is increased from 369 miles to 520 miles, and the recovery payload from 5,523 pounds to 9,000 pounds.

They also incorporate two additional weapon stations that provide increased payload flexibility by mixing and matching air-to-air and/or air-to-ground ordnance, including "smart" weapons like the JDAM JSOW. The F/A-18 E/F also has some stealth features. Although the more recent F/A-18C/D aircraft has incorporated some low observables technology, the F/A-18E/F was designed from the outset to optimize such features. It also has a new Advanced Targeting Forward-Looking Infra-Red (ATFLIR), the baseline infrared system pod that features both navigation and infrared targeting systems, incorporating third-generation mid-wave infrared (MWIR) staring focal plane technology.[262]

Vice Admiral Timothy Keating, commander of all maritime forces involved in Operation Iraqi Freedom, described the range-payload advantages of the new F/A-18E/F as follows in a briefing on April 12, 2003:

> We've had the introduction of the F-18 E and F, our new Super Hornet, which has longer legs. It can fly further, it can carry more ordnance. It has some very sophisticated radar and electronic improvements, so it has proven—and it can also, by the way, carry a tanker store to pass gas to other airplanes airborne, which goes back, I think, to Dale's question about gas airborne. We've been able to flex a little bit with the F-18 E/F and…accomplish even more missions that we could

in 1991.

The Issue of Survivability in Future Wars

Once again, questions must be asked as to whether bombers and heavily loaded strike fighters would have been as able to survive as well against an enemy with better air defense or land-based air defense systems. At the same time, few nations have such capabilities, and the USAF has shown that bombers can be steadily modified and upgraded..[263] It is clear that strike-fighter range-payload and the ability to carry and deliver large numbers of precision-guided munitions and either fire at standoff ranges or use stealth is a key aspect of fighter performance. Moreover, it is one that is gaining importance relative to advanced air combat maneuver capability in a world where so few air forces have anything like peer capability in air combat, and where air-to-air encounters increasingly occur at ranges beyond "dogfight" direct maneuver encounters. The Iraq War at least raises the possibility that trade-offs may been needed between an air superiority fighter like the F-22 and new strike-attack fighters like the JSF and FB-22.[264]

The Role of the E-8C JSTARS

There are no combat operations data available in a form where that makes it possible to precisely define the role of sensor aircraft like the E-8C JSTARS, or Joint Surveillance and Target Attack Radar System. It is clear, however, that extensive use was made of JSTARS. The Coalition's air dominance allowed it to be deployed forward and nearer the battle space, where it could track Iraqi armored and vehicle movements over hundreds of square miles, and it was used to cover the greater Baghdad area. The "fusion of intelligence" from the E-8C and other sources enabled the coalition to locate and target Iraq forces under weather conditions the Iraqis felt protected them from the air. Aircraft like the RC-135 Rivet Joint, for example, could characterize and locate the source of Iraqi military communications.[265]

The Evolving Capabilities of JSTARS

The Joint Surveillance and Target Attack Radar System is also a symbol of the rapidly evolving role of jointness in the air-land battle. A technical description of the aircraft is in many ways a technical description of the new IS&R, C4I, and battle management techniques that shape the evolving U.S. approach to war.

JSTARS is a joint development project of the U.S. Air Force and U.S. Army that provides an airborne, stand-off range, surveillance and target acquisition radar and command and control center.[266] It was used experimentally in the Gulf War. In September 1996, JSTARS was approved for full-rate production for 14 aircraft, the last of which was delivered in August 2002. The first of three more aircraft was delivered in February 2003, and the USAF plans to acquire a total of 19.[267] The fully operational JSTARS was used for the first time to support peacekeeping operations in Bosnia-Herzegovina and during the Kosovo crisis.

The aircraft provides ground situation information through communication via secure data links with air force command posts, army mobile ground stations and centers of military analysis far from the point of conflict. It provides a picture of the ground situation equivalent to that of the air situation provided by AWACS. JSTARS is capable of determining the direction, speed, and patterns of military activity of ground vehicles and helicopters. The aircraft has a flight endurance of 11 hours or 20 hours with in-flight refueling.[268]

The radar system uses a 24-foot antenna installed on the underside of the aircraft, which is mechanically swiveled and pointed to scan in elevation, and scans electronically in azimuth to determine the location and heading of moving targets. The main operating modes of the radar are wide-area surveillance, fixed-target indication, synthetic aperture radar, moving target indicator, and target classification.

JSTARS aircraft have 17 operations consoles and one navigation/self-defense console. A console operator can carry out sector search focusing on smaller sectors and automatically track selected targets. Fixed high-value targets are detected through synthetic aperture radar (SAR). Signal processing techniques are implemented through four high-speed data processors, each capable of performing more than 600 million operations per second. Processed information is distributed via high-speed computer circuitry to tactical operators throughout the aircraft.

JSTARS has secure voice and datalinks to the Army's ground command and communications stations and to the Air Force command centers. Voice communications systems include 12 encrypted UHF radios, 2 encrypted HF radios, 3 VHF encrypted radios with provision for Single Channel Ground and Airborne Radio System (SINCGARS), and multiple intercom nets.

The digital datalinks include a satellite communications link (SATCOM), a surveillance and control datalink (SCDL) for transmission to mobile ground stations, and Joint Tactical Information Distribution System (JTIDS). The JTIDS provides tactical air navigation (TACAN) operation and Tactical Data Information Link-J (TADIL-J) generation and processing. The Cubic Defense Systems SCDL is a time-division multiple-access datalink incorporating flexible frequency management. The system employs wideband frequency hopping, coding, and data diversity to achieve robustness against hostile jamming. Uplink transmissions use a modulation technique to determine the path delay between the ground system module and the E-8C aircraft.

The aircraft will become significantly more effective in the future. The U.S. Air Force has awarded a contract to develop the next generation JSTARS as part of the Radar Technology Insertion Program (RTIP). The new, much more powerful radar will be an electronically scanned 2-D X-band active aperture radar that will have a helicopter detection mode and inverse synthetic aperture (ISAR) imaging capability, as well as MTI (moving target indicator) mode, allowing real-time imaging of moving objects.

In 1997, the U.S. Air Force awarded two contracts for a computer replacement program to take advantage of the latest commercial off-the-shelf technology (COTS). The program integrates new Compaq AlphaServer GS-320 central computers that are significantly faster than the original system. The programmable signal processors will be replaced and a high-capacity switch and fiber-optic cable will replace the copper-wired workstation network. The Computer Replacement Plan (CRP) has completed EMD testing and the first upgraded aircraft was delivered in February 2002.

Integrating JSTARS into Joint Warfare

There are many accounts in informal reports from U.S. Army and USAF forces in the theater as to the value of JSTARS during the Iraq War. The best formal account comes from the report on the lessons of the war by 1 Marine Division:[269]

> The presence of a JSTARS CGS at the Division had a tremendous positive effect for integrating this information into a comprehensive intelligence picture. The ability for the Div G-2 and Army CGS operators to work side-by-side allowed us to use the system in unconventional ways with tremendous tactically useful results. There was a critical requirement to monitor the potential movements of these enemy divisions in order to allow the 1st Marine Division move deep into the enemy battle space quickly.
>
> No other collection asset provided the wide area all weather coverage of the battle space that the JSTARS did with the MTI radar. Critical to our ability to use the capabilities of the JSTARS was the interface provided by the JSTARS Common Ground Station. The equipment allowed us to interact in real time with the collection platform and focus on our critical requirements and process the collection data into usable and actionable intelligence products. The soldiers who operated the system proved equally as critical as the equipment in processing, interpreting and translating operational requirements to the collection platform. Because they were close to the point of decision, these JSTARS operators shared the sense of urgency and ‘can-do’ attitude. They worked aggressively to find ways to answer questions instead of deflect them. When other platforms failed or were unavailable the CGS JSTARS combination ensured that we were not blind on the battlefield. JSTARS showed us enemy traffic over allegedly “no go” terrain, gave us estimated speeds of advance for our own forces by evaluating enemy speeds over that terrain, proved which bridges supported traffic, etc.
>
> The Marine Corps needs to invest the JSTARS MTI system and trained operators for provision down to the Division level…The Marine Corps needs to invest in the development of doctrine to request and employ the JSTARS MTI system. Need to acquire CGS systems and trained operators for provision down to the Division level with appropriate adjustment to the Division T/O and T/E.

It is noteworthy that the Marine Corps report again stresses the need for trained personnel, and for an effective tactical interface to make use of IS&R assets. It is much easier to improve collection and senor platforms than it is to integrate their output into effective war-fighting capability.

Unmanned Aerial Vehicles (UAVs)

While no sortie data are available on the Coalition’s use of UAVs, the nature and importance of the data they collected, or the specifics of the role they played in joint operations, it is clear that they had a major impact. The Coalition used more than a dozen types of UAVs in the conflict, building on the U.S. success in using such systems in Afghanistan.[270]

The UAVs included larger systems like the Predator, Global Hawk, and the Pointer, the three systems the United States used in Afghanistan. The United States had used the Pioneer in the Gulf War. In the Iraq War, the Coalition also made use of new tactical systems like the U.S. Army Hunter and Shadow, the Marine Corp’s Dragon Eye, and the USAF Force Protection Surveillance System. The change was particularly important in the case of field commanders, who had only one type of UAV available in the Gulf War but had 10 types available in the Iraq War.[271] Both the US military services and the Britain Ministry of Defense concluded that the value of these UAVs was one of the major lessons of the war.[272]

The Predator

The upgraded RQ-1 Predator UAV carries the Multispectral Targeting System (MTS) with inherent AGM-114 Hellfire missile-targeting capability, and integrates electro-optical, infrared, laser designator, and laser illuminator into a single sensor package. The Predators cannot carry MTS and a synthetic aperture radar, or SAR, simultaneously. The aircraft can carry and employ two laser-guided Hellfire anti-tank missiles with MTS.

The Predator has a cruise speed of around 84 mph (70 knots), and a maximum speed of up to 135 mph. It has a range of up to 400 nautical miles (454 miles), a ceiling of up to 25,000 feet (7,620 meters), and a payload of 450 pounds (204 kilograms). Its ability to loiter for up to 24 hours at altitudes of up to 15,000 feet also allowed it to support the ground battle and to be used to call in systems like the AC-130 gunship, A-10, and Tornado.

The Predator was flown to support virtually every major mission in the war, providing imagery day and night of a quality that under optimal conditions allows the user to distinguish between military civilian personnel at distances up to three miles. Some 15 Predators flew during the war, roughly one-third of the total fleet, and they flew more than 100 missions. These included joint missions such as using an RC-135 Rivet Joint electronic warfare aircraft to locate the area of an Iraqi surface-to-air missile and then sending a Predator to find the target and send back its precise coordinates. Even when not armed with Hellfire missiles, the Predator served as an effective means of improving targeting and strike reaction times.

An armed version of the Predator, the MQ-1, fired more than 12 Hellfire missiles against Iraqi targets during the course of the war.[273] The US also equipped some Predators with Stinger air-to-air missile. It did so because a Predator had also flown a mission several months before the war in which an Iraqi Mig-25 fired two air-to-air missiles and shot down the Predator. The Predator had, however, been able to fire two Stinger air-to-air missiles in response and transmit video images of the engagement. While this encounter showed that the Predator was vulnerable in spite of its relatively small visual and radar profile, it also showed that unmanned aerial combat vehicles (UCAVs) could be given a limited self-defense capability.[274]

The Global Hawk

The Global Hawk Unmanned Aerial Vehicle (UAV) provides joint battlefield commanders with near-real-time, high-resolution intelligence, surveillance, and reconnaissance imagery. It cruises at extremely high altitudes and can survey large geographic areas with pinpoint accuracy to provide information about enemy location, resources, and personnel. Once mission parameters are programmed into the Global Hawk, the UAV can autonomously taxi, take off, fly, remain on station capturing imagery, return, and land. Ground-based operators monitor UAV health and status and can change navigation and sensor plans during flight as necessary.

The aircraft has a wingspan of 116 feet (35.3 meters) and is 44 feet (13.4 meters) long. It can range as far as 12,000 nautical miles, at altitudes up to 65,000 feet (19,812 meters), flying at speeds approaching 340 knots (about 400 mph) for as long as 35 hours. During a typical mission, the aircraft can fly 1,200 miles to an area of interest and remain on station for 24 hours. Its cloud-penetrating Synthetic Aperture Radar/Ground Moving Target Indicator electro-optical and infrared sensors can image an area the size of Illinois (40,000 nautical square miles) in just 24 hours, and it can image some 200–300 sites on a single sortie. Through satellite and ground systems, the imagery can be relayed in near-real-time to battlefield commanders.[275]

The Global Hawk operated at higher altitudes than the Predator, and its radar imagery allowed it to function even during sandstorms. One aircraft was deployed, and it flew missions every day of the war. It operated out of the United Arab Emirates (UAE) and was controlled from Beale Air Force Base in California. It was used for time-sensitive targeting, which was coordinated through the CAOC in Saudi Arabia. The synthetic aperture radar proved to be particularly useful in targeting even static ground forces, like elements of the Medina Division that were still in revetments.[276]